



**CHEMISTRY  
HIGHER LEVEL  
PAPER 1**

Wednesday 4 May 2005 (afternoon)

1 hour

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**INSTRUCTIONS TO CANDIDATES**

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.

The Periodic Table

0

6

5

4

3

The Periodic Table

2

1

Atomic Number		Element										Atomic Mass	
1 <b>H</b> 1.01													2 <b>He</b> 4.00
3 <b>Li</b> 6.94	4 <b>Be</b> 9.01												9 <b>F</b> 19.00
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31												17 <b>Cl</b> 35.45
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.90	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.71	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.37		35 <b>Br</b> 79.90
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> 98.91	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.40		53 <b>I</b> 126.90
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.34	57 † <b>La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.85	75 <b>Re</b> 186.21	76 <b>Os</b> 190.21	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.09	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59		85 <b>At</b> (210)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 ‡ <b>Ac</b> (227)											86 <b>Rn</b> (222)

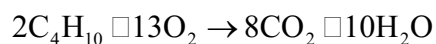
†													
58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> 146.92	62 <b>Sm</b> 150.35	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.92	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97

‡													
90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (242)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (254)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

†

‡

1. The equation for the complete combustion of butane is



What is the amount (in mol) of carbon dioxide formed by the complete combustion of three moles of butane?

- A. 4
- B. 8
- C. 12
- D. 24

2. Which solution contains the greatest amount (in mol) of solute?

- A. 10.0 cm<sup>3</sup> of 0.500 mol dm<sup>-3</sup> NaCl
- B. 20.0 cm<sup>3</sup> of 0.400 mol dm<sup>-3</sup> NaCl
- C. 30.0 cm<sup>3</sup> of 0.300 mol dm<sup>-3</sup> NaCl
- D. 40.0 cm<sup>3</sup> of 0.200 mol dm<sup>-3</sup> NaCl

3. How many oxygen atoms are present in 0.0500 mol carbon dioxide?

- A. 3.01 × 10<sup>22</sup>
- B. 6.02 × 10<sup>22</sup>
- C. 6.02 × 10<sup>23</sup>
- D. 1.20 × 10<sup>24</sup>

4. How many electrons are there in one  $^{24}_{12}\text{Mg}^{2+}$  ion?

- A. 10
- B. 12
- C. 14
- D. 22

5. How many electrons are there in **all** the d orbitals in an atom of xenon?
  - A. 10
  - B. 18
  - C. 20
  - D. 36
  
6. What increases **in equal steps of one** from left to right in the periodic table for the elements lithium to neon?
  - A. the number of occupied electron energy levels
  - B. the number of neutrons in the most common isotope
  - C. the number of electrons in the atom
  - D. the atomic mass
  
7. Which **two** elements react most vigorously with each other?
  - A. chlorine and lithium
  - B. chlorine and potassium
  - C. iodine and lithium
  - D. iodine and potassium
  
8. Which is an essential feature of a ligand?
  - A. a negative charge
  - B. an odd number of electrons
  - C. the presence of two or more atoms
  - D. the presence of a non-bonding pair of electrons

9. What happens when sodium and oxygen combine together?
- A. Each sodium atom gains one electron.
  - B. Each sodium atom loses one electron.
  - C. Each oxygen atom gains one electron.
  - D. Each oxygen atom loses one electron.
10. In ethanol,  $\text{C}_2\text{H}_5\text{OH}(\text{l})$ , there are covalent bonds, hydrogen bonds and van der Waals' forces. Which bonds or forces are broken when ethanol is vaporized?
- A. only hydrogen bonds
  - B. covalent bonds and hydrogen bonds
  - C. covalent bonds and van der Waals' forces
  - D. hydrogen bonds and van der Waals' forces
11. Which statement best describes the attraction present in metallic bonding?
- A. the attraction between nuclei and electrons
  - B. the attraction between positive ions and electrons
  - C. the attraction between positive ions and negative ions
  - D. the attraction between protons and electrons

12. Which statement is correct about multiple bonding between carbon atoms?
- A. Double bonds are formed by two  $\pi$  bonds.
  - B. Double bonds are weaker than single bonds.
  - C.  $\pi$  bonds are formed by overlap between s orbitals.
  - D.  $\pi$  bonds are weaker than sigma bonds.
13. Which statements are correct about diamond, graphite and a  $C_{60}$  fullerene?
- I. The poorest electrical conductor of the three is diamond.
  - II. The atoms in graphite and  $C_{60}$  fullerene are  $sp^2$  hybridized.
  - III. The atoms in diamond and  $C_{60}$  fullerene are arranged in hexagons.
- A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
14. A fixed mass of an ideal gas has a volume of  $800\text{ cm}^3$  under certain conditions. The pressure (in kPa) and temperature (in K) are both doubled. What is the volume of the gas after these changes with other conditions remaining the same?
- A.  $200\text{ cm}^3$
  - B.  $800\text{ cm}^3$
  - C.  $1600\text{ cm}^3$
  - D.  $3200\text{ cm}^3$

15. Which statements are correct for an endothermic reaction?

- I. The system absorbs heat.
- II. The enthalpy change is positive.
- III. The bond enthalpy total for the reactants is greater than for the products.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

16. The average bond enthalpy for the C—H bond is  $412 \text{ kJ mol}^{-1}$ . Which process has an enthalpy change closest to this value?

- A.  $\text{CH}_4(\text{g}) \rightarrow \text{C}(\text{s}) + 2\text{H}_2(\text{g})$
- B.  $\text{CH}_4(\text{g}) \rightarrow \text{C}(\text{g}) + 2\text{H}_2(\text{g})$
- C.  $\text{CH}_4(\text{g}) \rightarrow \text{C}(\text{s}) + 4\text{H}(\text{g})$
- D.  $\text{CH}_4(\text{g}) \rightarrow \text{CH}_3(\text{g}) + \text{H}(\text{g})$

17. Some chlorine gas is placed in a flask of fixed volume at room temperature. Which change will cause a decrease in entropy?

- A. adding a small amount of hydrogen
- B. adding a small amount of chlorine
- C. cooling the flask
- D. exposing the flask to sunlight

18. Which type of reaction is referred to in the definition of *standard enthalpy change of formation*?

- A. the formation of a compound from its elements
- B. the formation of a crystal from its ions
- C. the formation of a molecule from its atoms
- D. the formation of a compound from other compounds

19. The reaction between calcium carbonate and hydrochloric acid, carried out in an open flask, can be represented by the following equation.



Which of the measurements below could be used to measure the rate of the reaction?

- I. the mass of the flask and contents
- II. the pH of the reaction mixture
- III. the volume of carbon dioxide produced

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

20. The rate expression for a particular reaction is

$$\text{Rate} = k[\text{P}][\text{Q}]$$

Which of the units below is a possible unit for  $k$ ?

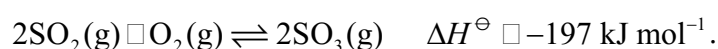
- A.  $\text{mol}^{-2} \text{dm}^6 \text{min}^{-1}$
- B.  $\text{mol}^{-1} \text{dm}^3 \text{min}^{-1}$
- C.  $\text{mol dm}^{-3} \text{min}^{-1}$
- D.  $\text{mol}^2 \text{dm}^{-6} \text{min}^{-1}$



21. Which statement is correct about the behaviour of a catalyst in a reversible reaction?

- A. It decreases the enthalpy change of the forward reaction.
- B. It increases the enthalpy change of the reverse reaction.
- C. It decreases the activation energy of the forward reaction.
- D. It increases the activation energy of the reverse reaction.

22. The manufacture of sulfur trioxide can be represented by the equation below.



What happens when a catalyst is added to an equilibrium mixture from this reaction?

- A. The rate of the forward reaction increases and that of the reverse reaction decreases.
- B. The rates of both forward and reverse reactions increase.
- C. The value of  $\Delta H^\ominus$  increases.
- D. The yield of sulfur trioxide increases.

23. A sealed container at room temperature is half full of water. The temperature of the container is increased and left for equilibrium to re-establish. Which statement is correct when the equilibrium is re-established at the higher temperature?

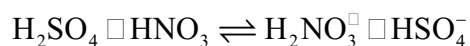
- A. The rate of vaporization is greater than the rate of condensation.
- B. The amount of water vapour is greater than the amount of liquid water.
- C. The amount of water vapour is greater than it is at the lower temperature.
- D. The rate of condensation is greater than the rate of vaporization.

24. Which methods will distinguish between equimolar solutions of a strong base and a strong acid?

- I. Add magnesium to each solution and look for the formation of gas bubbles.
- II. Add aqueous sodium hydroxide to each solution and measure the temperature change.
- III. Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

25. The equation for the reaction between nitric acid and sulfuric acid is shown below.



Which species are acting as acids in this reaction according to the Brønsted-Lowry theory?

- A.  $\text{H}_2\text{SO}_4$  and  $\text{HNO}_3$
- B.  $\text{H}_2\text{SO}_4$  and  $\text{H}_2\text{NO}_3^+$
- C.  $\text{HNO}_3$  and  $\text{H}_2\text{NO}_3^+$
- D.  $\text{H}_2\text{NO}_3^+$  and  $\text{HSO}_4^-$

26. Which values are correct for a solution of NaOH of concentration  $0.010 \text{ mol dm}^{-3}$  at 298 K?

$$(K_w = 1.0 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6} \text{ at } 298 \text{ K})$$

- A.  $[\text{H}^+] = 1.0 \times 10^{-2} \text{ mol dm}^{-3}$  and  $\text{pH} = 2.00$
- B.  $[\text{OH}^-] = 1.0 \times 10^{-2} \text{ mol dm}^{-3}$  and  $\text{pH} = 12.00$
- C.  $[\text{H}^+] = 1.0 \times 10^{-12} \text{ mol dm}^{-3}$  and  $\text{pOH} = 12.00$
- D.  $[\text{OH}^-] = 1.0 \times 10^{-12} \text{ mol dm}^{-3}$  and  $\text{pOH} = 2.00$

27. Which solution, of concentration  $0.10 \text{ mol dm}^{-3}$ , has the highest pH value?

- A.  $\text{HCl(aq)}$
- B.  $\text{MgCl}_2(\text{aq})$
- C.  $\text{NaCl(aq)}$
- D.  $\text{AlCl}_3(\text{aq})$

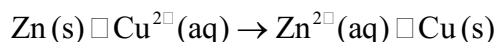
28. Which statement about indicators is **always** correct?

- A. The mid-point of an indicator's colour change is at  $\text{pH} \approx 7$ .
- B. The pH range is greater for indicators with higher  $\text{p}K_{\text{a}}$  values.
- C. The colour red indicates an acidic solution.
- D. The  $\text{p}K_{\text{a}}$  value of the indicator is within its pH range.

29. What are the oxidation numbers of the elements in sulfuric acid,  $\text{H}_2\text{SO}_4$ ?

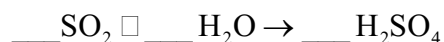
	Hydrogen	Sulfur	Oxygen
A.	<input type="text"/>	<input type="text"/>	<input type="text"/>
B.	<input type="text"/>	<input type="text"/>	<input type="text"/>
C.	<input type="text"/>	<input type="text"/>	<input type="text"/>
D.	<input type="text"/>	<input type="text"/>	<input type="text"/>

30. A voltaic cell is made from copper and zinc half-cells. The equation for the reaction occurring in the cell is



Which statement is correct when the cell produces electricity?

- A. Electrons are lost from zinc atoms.
  - B. The mass of the copper electrode decreases.
  - C. Electrons flow from the copper half-cell to the zinc half-cell.
  - D. Negative ions flow through the salt bridge from the zinc half-cell to the copper half-cell.
31. The **unbalanced** equation for the conversion of sulfur dioxide to sulfuric acid is given below.



Which other species are used, and on which side of the equation, to balance it?

- A.  $\text{H}^+$  and  $\text{e}^-$  on the left
  - B.  $\text{H}^+$  on the left and  $\text{e}^-$  on the right
  - C.  $\text{H}^+$  on the right and  $\text{e}^-$  on the left
  - D.  $\text{H}^+$  and  $\text{e}^-$  on the right
32. Which is a feature of the standard hydrogen electrode?
- A. hydrogen gas at  $1.01 \times 10^5$  Pa (1 atm) pressure
  - B.  $1.0 \text{ mol dm}^{-3}$  sulfuric acid
  - C. a temperature of 273 K
  - D. a magnesium electrode

33. Which pair of factors both affect the amount (in mol) of chlorine produced in the electrolysis of aqueous sodium chloride?
- A. current and temperature
  - B. temperature and chloride ion concentration
  - C. chloride ion concentration and length of time of electrolysis
  - D. pressure and length of time of electrolysis
34. Which compound is a member of the same homologous series as 1-chloropropane?
- A. 1-chloropropene
  - B. 1-chlorobutane
  - C. 1-bromopropane
  - D. 1,1-dichloropropane
35. Which formula is a correct representation of pentane?
- A.  $\text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_3$
  - B.  $(\text{CH}_3\text{CH}_2)_2\text{CH}_3$
  - C.  $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$
  - D.  $\text{CH}_3(\text{CH}_3)_3\text{CH}_3$
36. What is the organic product of the reaction between ethanol and ethanoic acid?
- A.  $\text{CH}_3\text{CHO}$
  - B.  $\text{CH}_3\text{COOCH}_3$
  - C.  $\text{CH}_3\text{CH}_2\text{COOCH}_3$
  - D.  $\text{CH}_3\text{COOCH}_2\text{CH}_3$

37. Propanal,  $\text{CH}_3\text{CH}_2\text{CHO}$  ( $M_r = 58$ ), undergoes complete fragmentation in a mass spectrometer. What is the  $m/z$  value of the most intense line in its mass spectrum?
- A. 15  
B. 29  
C. 43  
D. 58
38. Which statement is correct about the reaction between methane and chlorine?
- A. It involves heterolytic fission and  $\text{Cl}^-$  ions.  
B. It involves heterolytic fission and  $\text{Cl}^\bullet$  radicals.  
C. It involves homolytic fission and  $\text{Cl}^-$  ions.  
D. It involves homolytic fission and  $\text{Cl}^\bullet$  radicals.
39. Which formula is that of a secondary halogenoalkane?
- A.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$   
B.  $\text{CH}_3\text{CHBrCH}_2\text{CH}_3$   
C.  $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$   
D.  $(\text{CH}_3)_3\text{CBr}$
40. Which compound is converted to butanal by acidified potassium dichromate(VI) solution?
- A. butan-1-ol  
B. butan-2-ol  
C. butanone  
D. butanoic acid
-